**Perception of Barefoot Performance**

Senior Thesis

Presented in Partial Fulfillment of the Requirements for Graduation "with Research Distinction in Education and Human Ecology" in the Health and Exercise Science Department of The Ohio State University

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The Ohio State University, May 2013

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**Acknowledgements**

I would like to thank Dr. Swain and Dr. Focht for their support and guidance throughout this research project.

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**ABSTRACT**

The phenomenon known as 'barefoot running' has made a recent comeback. In response to the barefoot running craze, a 'shoe' has been developed to allow runners to train "barefoot" but provide some basic protection. Many runners that have used these shoes and claim improved performance and less injury. Previous research suggests barefoot running may alleviate injuries by altering biomechanics. The performance and psychological aspects of running in minimalist shoes (BAREFOOT) compared to traditional shoes (SHOD) is less understood. **PURPOSE**: To examine differences that may exist in performance and subjective ratings during a race situation in the BAREFOOT and SHOD conditions. **METHODS**: Fourteen male, trained BAREFOOT participants engaged in a 2-mile time trial (RACE) to the best of their ability. Subjects randomly performed the RACE on a treadmill during two separate occasions, BAREFOOT and SHOD. Subjects controlled speed using an up or down button, but were blinded to the running speed and time to completion. Subjects were asked every half-mile to responds to the Feeling Scale (FS) and Rating of Perceived Exertion Scale (RPE). A qualitative questionnaire was administered to gather information related to motivation and subjective responses to running in the BAREFOOT condition. Paired-T tests were used to examine differences between conditions, alpha was set at $p<0.05$. **RESULTS**: No significant differences were found for time to completion and RPE measures. The BAREFOOT condition scored significantly higher ($p=0.011$) on the FS compared to SHOD condition. A standardized scale was created by combining RPE and FS, which resulted in significant higher results ($p=0.013$) for BAREFOOT condition compared to SHOD. **CONCLUSIONS**: Running in a minimalist shoe feels easier for those who have trained in them. Trained BAREFOOT runners feel better at all levels of effort in the BAREFOOT condition, despite no improvements in race time.

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## 1. INTRODUCTION

Previous research suggests Barefoot Running may alleviate injuries and possibly improve performance. In response to the barefoot running craze, shoe companies have developed a strategy to allow runners to train "barefoot" but provide some basic protection.

The Vibram-Finger shoe, designed by Robert Fliri, emulates the idea of barefoot running because of its minimal weight, and sock like fit. The Five-Fingers are marketed towards preventing injuries and enhancing fitness levels, "promoting better foot health and stimulating the muscles in the feet and lower legs for greater balance, agility and strength." Five-Finger shoes are revolutionary providing a new approach to the barefoot style of running.

Robert Fliri makes an interesting point in regards to mood and exercise in these minimalist shoes during an interview (Milan, Italy 2006). Fliri reported the major difference between Five-Fingers and traditional shoes is the individual toe slots, which enable the wearer to move more freely and establishes more body-smartness; "you can move and feel better, and have more power," says Fliri. Additionally, Fliri claims that it is "joyful to move around in Five-Fingers and that you will actually become happy to move". The design of this shoe is targeted towards a natural feel, Fliri's comments regarding this design imply that a result of wearing Five-Fingers promote feelings of pleasure like happiness and a sense of power.

There has been little investigation, and no apparent published data examining the performance and subjective characteristics of running barefoot. It has been suggested that this form of running is more efficient and possibly that people run faster or better in this condition. These aspects will be examined to better understand the differences between running barefoot and shod. To reduce the risk of musculoskeletal injury only experienced barefoot runners will be

utilized in this study. Physiological and subjective characteristics will be examined during a 'race' condition both barefoot and shod.

**LITERATURE REVIEW**

The style of Barefoot Running is a way of life in some countries across the world. In the non-fiction novel, Born To Run, Christopher McDougall explores the running techniques of the Tarahumara Indian Tribe, in Mexico. The Tarahumara people have been running barefoot since the beginning of their time, and have been doing it well. The Tarahumara people are able to run hundreds of miles while barefoot without experiencing running injuries. It has been suggested by many, that their way of running could serve as a model for the most efficient way to run.

More efficient may mean less injury for the average runner. Many people think wearing shoes will ensure greater protection from injuries. The majority of runners today train with running shoes. It wasn't until recently that the thick supportive arches in running shoes became popular, "…they were invented only in the 1970s. Before then, running shoes were just simple running flats that had little cushioning, no arch support, and no built-up heel (McDougall, 2009)."

With this being said, the design of running shoes has not been proven to enhance athlete's ability to run. The amount of injuries recorded yearly has not declined with the advancement of what is now considered the modern day running shoe. There is no evidence that directly links shoes with injuries, although there are many statistics that show the frequency of running injuries related to shoes. Almost all dedicated runners have suffered from some type of injury, "every year 8 out of 10 runners are injured (McDougall, 2009)."

The mechanics of running are complicated, even elite trained athletes are not immune to injuries. The idea behind barefoot running embraces the natural form of running allowing the

underused muscles in the foot to strengthen. Studies have been performed to examine the foot strike while running barefoot; in fact, the majority of barefoot running studies examine gait analysis and the mechanical reactions to working in this condition. Conclusions from these studies suggest that barefoot running creates a different 'running gait', which transforms runners stride to a *forefoot* strike rather than a *heel* foot strike (Lieberman, 2010). This condition is thought to be useful in the prevention of injuries. The injury prevention stems from lack of impact and the lack of potential torque caused by stumbling throughout a run.

In a Harvard Study, Biomechanics of Running, the difference in foot strike for barefoot vs. shod (shoes) runners were compared. Foot strike is important in running because it determines the force of impact. For instance: a heel strike runner can experience force up to, three times his/her body weight (Lieberman, 2010)." Most shod runners land on their heels in between strides. "Heel striking, the collision of the heel with the ground generates a significant impact transient, a nearly instantaneous, large force (Lieberman, 2010)." Running Barefoot promotes the *fore*foot strike, this style causes minimal impact on the lower half of the body, "the collision of the forefoot with the ground generates a very minimal impact force with no impact transient (Lieberman, 2010)." Without the excessive impact force from the heel strike, the forefoot strike could help alleviate the impact injuries resulting from running.

There may be reason to believe that running barefoot could benefit individuals through injury prevention (Robbins, 1995). Running barefoot allows muscles within the foot to strengthen; whereas, support from shoes can hinder this process, "Excessive cushioning reduces the amount of information (neural muscular signals) that your body receives through the feet, and you will lose a certain percentage of strength and flexibility as a result (McDougall, 2009)." Barefoot runners also land mid-foot, increasing the work of the foot's soft tissue support

structures, thereby increasing their strength and possibly reducing the risk of injury (Yessiss, 2000).

The biomechanics of the stride is not the only factor that influences performance. The psychological or subjective component is also an important aspect of exercise. This mental component is considered crucial for overall performance. The mood of an individual has been shown to have a significant outcome on performance. Positive emotions are associated with success and the ability to succeed.

"Positive emotions increase people's physical, cognitive and social resources, which in turn help them cope more effectively with stressful experiences (Frederickson, 2001)." While, negative emotions actually affect the endocrine system releasing toxins in the blood stream resulting in poor performance (Nudel, 2002). It is important for competitors to keep a positive attitude in order to compete at their best ability.

A study conducted by the Journal of Health Management tested how the level of positive affect can cause a change in psychological resilience, physical health and psychological well-being. Positive affect significantly influences these factors; a person that demonstrates positive affect is thought to have 'more flexible thinking' (Nath, 2012). Researchers have found that flexible thinking characterizes psychological resilience, which leads to improved physical health and psychological well-being. The results of the study conducted by Papri revealed that positive affectivity leads to better physical health and enhanced psychological well-being. It has been documented by many researchers that physical health benefits result from positive effect.

Research has been done in regards to Sports Psychology to find out how emotions can affect sport performance. Author, Krahenbuhl Williams claims that short-term fluctuation in running economy is closely tied to mood state. Moreover, a person's 'psychological state' is thought to

affect overall performance level during competition. An optimal psychological state is considered necessary to be prepared for competition; this includes emotions and cognitions relating to self-confidence, motivation, anxiety, and attention (Hardy, 1996). Optimal psychological states are dependent on several criteria: the athlete, task, and environment (Newell, 1986). The combination of these factors will determine an individual's psychological state.

A psychological state is maintained throughout a competition by using different psychological skills to regulate confidence, motivation, anxiety, and attention (Hardy, 1996). It is often difficult to manage different emotions throughout a competition, but finding an optimum psychological state may help an individual manage these emotions and focus on their performance.

Anxiety and stress are two common emotions experienced while preparing and performing in a competition. A lot of athletes form psychological routines before competing to reduce their level of stress or anxiety. Some studies have found neurophysiological evidence to support the significance of the psychological routines (examples: goal setting, imagery, and self-talk) (Hardy, 1996). The brain activity level in individuals that have established such methods is considerably less than the individuals that have not. Those who established their psychological routines experience less distraction, which could affect their performance.

A study conducted by Milton, Solodkin, Hluštík, and Small (2007) used functional magnetic resonance imaging (fMRI) to assess brain activity in golfers during their preparation phase. The more experienced golfers actually had less activity occurring in the emotional parts of the brain (limbic system and basal ganglia) during performance. The activity was found in the areas related to motor control (pre motor areas) (Milton, Solodkin, Hluštík, & Small 2007). Energy

should be used as efficiently as possible during competition to increase performance levels. Experienced athletes seem to display less activity in the emotional parts of the brain; therefore, they are less likely to undergo emotional distractions.

There are different tactics that are used in preparation for competition and this preparation may differ between athletes depending on their sport. Running is an individual sport and the preparation for an endurance event would be different than preparing for a team event. The book, Mind-Body Maturity: Psychological Approaches to Sports, Exercise, and Fitness, suggests that runners let the event induce the psychological state; additionally, it is suggested that the runner may also be attempting to reduce any pain from the run, but letting the body make the adjustment as needed. The runner is using physical effort of the exercise to induce the mood alteration. The point being made here is highlighting an interaction between psychological and physiological states and their affect one each other.

Another possible connection between psychological and physiological state is the effect of neurotransmitters released during exercise in regards to overall well-being. Researchers used to believe endorphins were responsible for such elevated moods during exercise, but after more research discredited this theory it no longer holds significance. For example, in some studies when the effects of endorphins were blocked chemically, people still experienced a 'runner's high'; therefore, some other neurotransmitters may be responsible for the elevation in mood, Cedric Bryant, PhD. The term runner's high is a common phrase claimed by the increased sense of well-being while running for an extended period of time.

Some neurotransmitters that are produced in higher concentrations during exercise are serotonin, norepinephrine, dopamine, and secretion; these neurotransmitters have been shown to

help reduce depression, Cedric Bryant, PhD. Therefore, some of these substances may be responsible for the sense of well-being during exercise.

## 2. METHODOLOGY

An IRB application was completed and approved prior to study initiation. Fourteen male BAREFOOT runners, aged 18-30, were recruited for this study. The subjects had completed at least four months of training in Vibram Five-Finger shoes (trained runners). Attaining subjects for this study was manageable due to the large running community in Columbus, Ohio. There were numerous endurance running clubs, competitive athletics and races dedicated to the sport within The Ohio State University community. Participants were recruited through local running stores, running clubs, and utilizing internet advertisement.

Before participating in the research study, the subjects completed the Health Screening for Physical Activity Participation and the Informed Consent. Subjects were then oriented to the research project, which included introduction of the researcher, an explanation of the resting procedures and subject expectations.

Subjects were males ages 18-30, who were trained Five-Finger (BAREFOOT) runners. Each subject visited the lab on two occasions (within a 5-10) day period) and randomly performed fitness testing either BAREFOOT or in traditional running shoes (SHOD). The subjects took a pre-test questionnaire related to barefoot running experiences.

Subjects were asked to perform a 2-mile race on the treadmill. Time to completion and subjective measures were made during the race. Subjects were given a ½ mile warm-up period, followed by the race, and a cool-down. During the race, the subject was able to adjust the treadmill speed by using the up and down arrows, in an effort to achieve their best possible to completion. Time elapsed and velocity data was withheld from the subject.

Rating of perceived exertion (RPE) and the feeling scale (FS) were used to measure individual perception of intensity and pain, while running a 2-mile race. The Rating of Perceived Exertion Scale (RPE) indicates a measure of how hard the subject is working. In a similar manner, the pain level for both running styles will be determined and compared through the Feeling Scale (FS). The effects of pain can lead to injuries; these injuries could be prevented through information received from the FS. Subjects were asked to express their RPE, and where they ranked on the FS at every ½ mile throughout the race. Subjects were informed of their progress (i.e., at each ½ mile) prior to the RPE and FS measurement.

These subjective results and time to completion were compared in both trials (BAREFOOT/SHOD). In addition, a standardized scale, combining both RPE and FS measures, was compared in BAREFOOT/SHOD trials. This scale was labeled Perception of Overall Performance (POP). Matched pairs student t-tests were used to examine significant differences between variables (time to completion and subjective ratings of perceived exertion, how subjects feel, and the combination of these measures) in both the BAREFOOT and SHOD condition.

**HYPOTHESIS**

The following null hypotheses were examined:

1. Time to completion in the barefoot condition will be equal to the shod condition.
2. Subjective variables (RPE, FS) will be unchanged in the barefoot and shod conditions.

## 3. RESULTS

The descriptive statistics refer to subject's sex, age, height, weight, and overall response's to barefoot running questionnaire. The information for the descriptive statistics can be found in **Table 1**. All fourteen subjects that participated in the study were males between the ages of 18-30. The average age was 22.71 years old ± 3.85 years. The average height was 70.71 ± 2.81 inches. The average weight was 171.54 lbs. ± 26.96 lbs. Several questions from the barefoot running questionnaire were reported in the table. One question revealed that 62% of the subject's claimed curiosity as their primary motivation to begin running in Five-Fingers. Additionally, half of the subjects stated they would still wear Five-Fingers even if research proved there were no physiological or time to completion differences in the Five-Finger (BAREFOOT) condition compared to regular running shoes. Also, 77% of subjects said they do not believe that wearing Five-Fingers was a fad that will fade out over time.

**TABLE 1**

| **Descriptive Stats** | |
|---|---|
| **Subjects:** | • 14 male participants |
| **Height:** | • Average: 70.71 inches<br>• Standard Deviation: 2.81 inches |
| **Weight:** | • Average: 171.54 lbs.<br>• Standard Deviation: 26.96 lbs. |
| **Age:** | • Average 22.71 years old<br>• Standard Deviation: 3.85 years |
| **Questionnaire Responses:** | • **62% of subjects** claimed ***curiosity*** was the primary reason they began running in Five-Fingers<br>• **Half of the subjects** stated they would still wear Five—Fingers even if research proved *no physiological or time to completion differences* in Five-Fingers compared to regular running shoes<br>• **77% of subjects** stated that Five-Fingers were not just a **"fad"** that will fade over time |

***Table 1*** *Descriptive Statistics relating to subject's height, weight, age, and questionnaire responses*

RPE, FS, POP, and time to completion measures for both barefoot and shod measures are compared in **Table 2**. The significance value was set at $P<0.05$; paired-T tests were used to determine all p values represented in **Table 2**. The mean RPE measure for barefoot runners was higher (14.66 ±1.64) than for shod runners (14.18 ±1.88). However, the p-value was 0.087, which indicates that the null hypothesis stating the differences between the barefoot and shod measures for the RPE scale would be equal, could not be rejected.

The mean FS measure for barefoot runners was higher (4.47±1.45) than for shod runners (0.61 ±1.71). The p-value of 0.011* indicates there is statistical significance to reject the null; subjects felt better running in the barefoot condition.

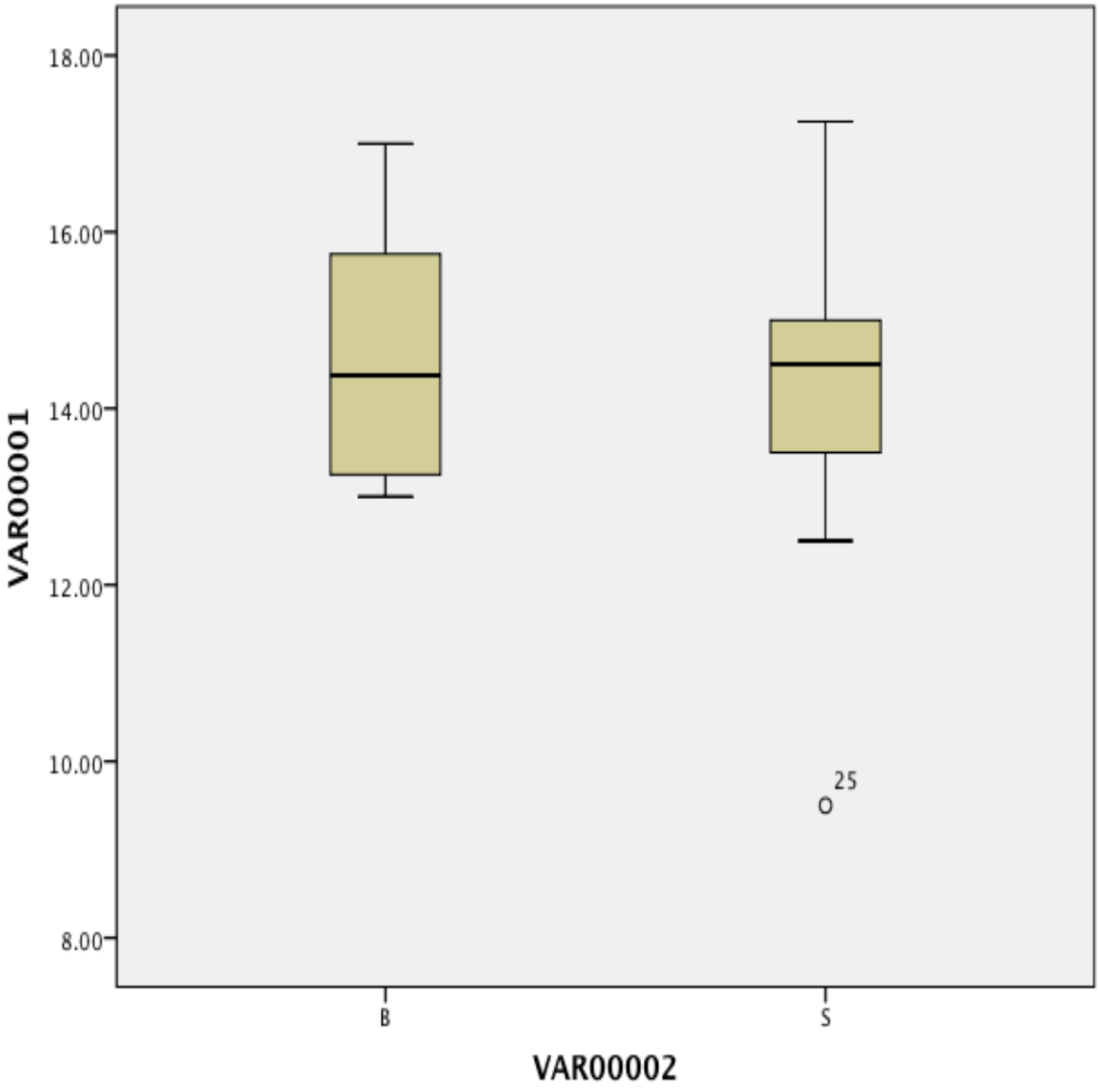
The mean POP scale measure for barefoot runners was higher (0.33±1.04) than for shod runners (-0.33±0.84) The p-value was 0.013*, from this value there was enough statistical significance to reject the null. The mean time to completion measure for barefoot runners was not significantly faster (17.40 min. ±3.43 min.) than the mean time to completion measure for shod runners (17.42 min. ±3.17 min).

**TABLE 2**

| **RPE Scale** | **BAREFOOT** | **SHOD** | **P-VALUE** |
|---|---|---|---|
| Mean | 14.66 | 14.18 | 0.087 |
| SD | 1.64 | 1.88 | |
| **Feeling Scale** | **BAREFOOT** | **SHOD** | **P-VALUE** |
| Mean | 4.47 | 0.61 | 0.011* |
| SD | 1.45 | 1.71 | |
| **Standardized Scale POP Scale (Perception of Overall Performance)** | **BAREFOOT** | **SHOD** | **P-VALUE** |
| Mean | 0.33 | -0.33 | 0.013* |
| SD | 1.04 | 0.84 | |
| **Time to Completion** | **BAREFOOT** | **SHOD** | **P-VALUE** |
| Mean | 17.40 min | 17.42 min | 0.094 |
| SD | 3.43 min | 3.17 min | |

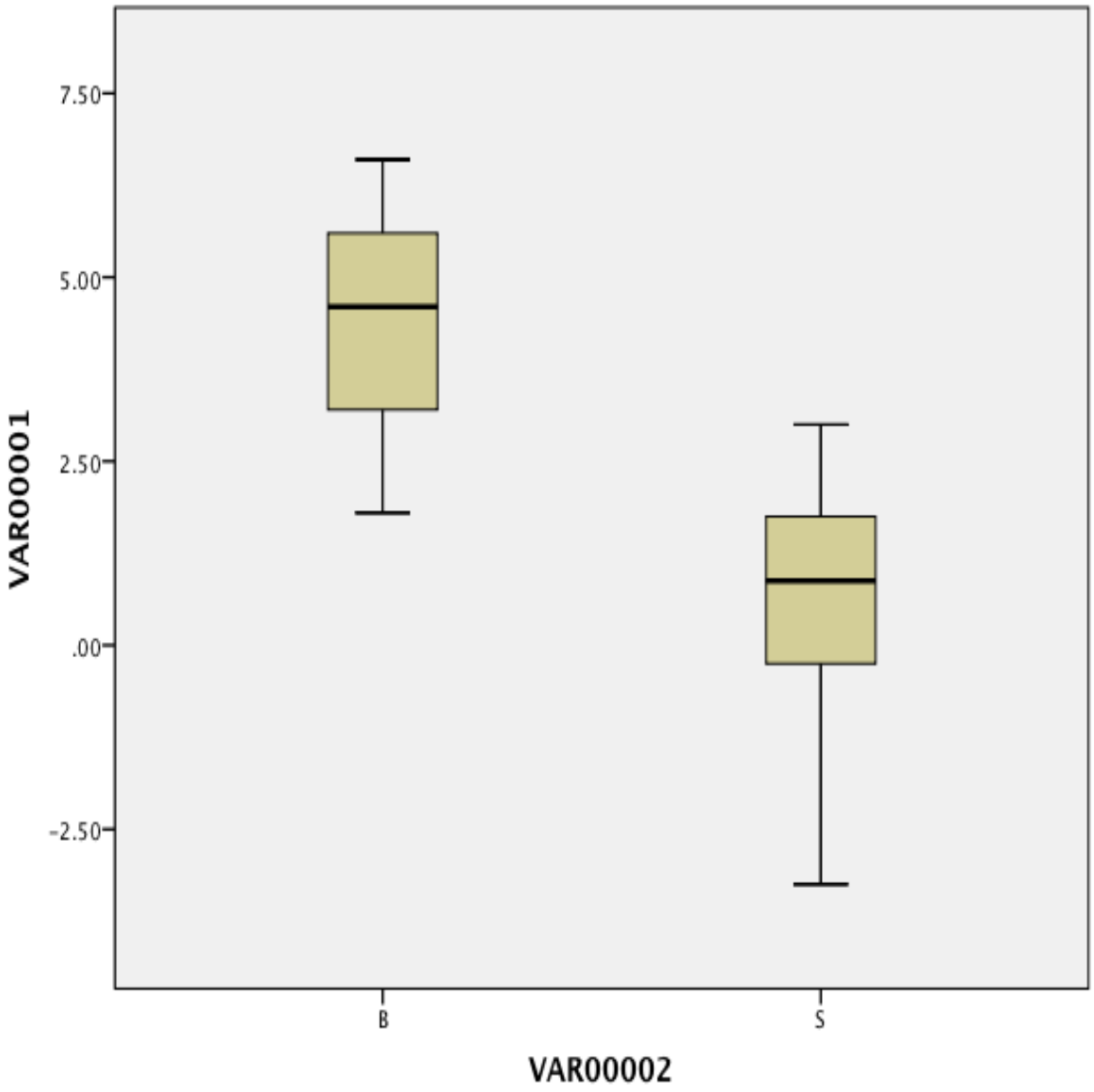
***Table 2*** *Mean, SD, and P-Value for RPE Scale, Feeling Scale, POP scale, and Time to Completion measures*

**RPE Measures for Barefoot and Shod Performance**



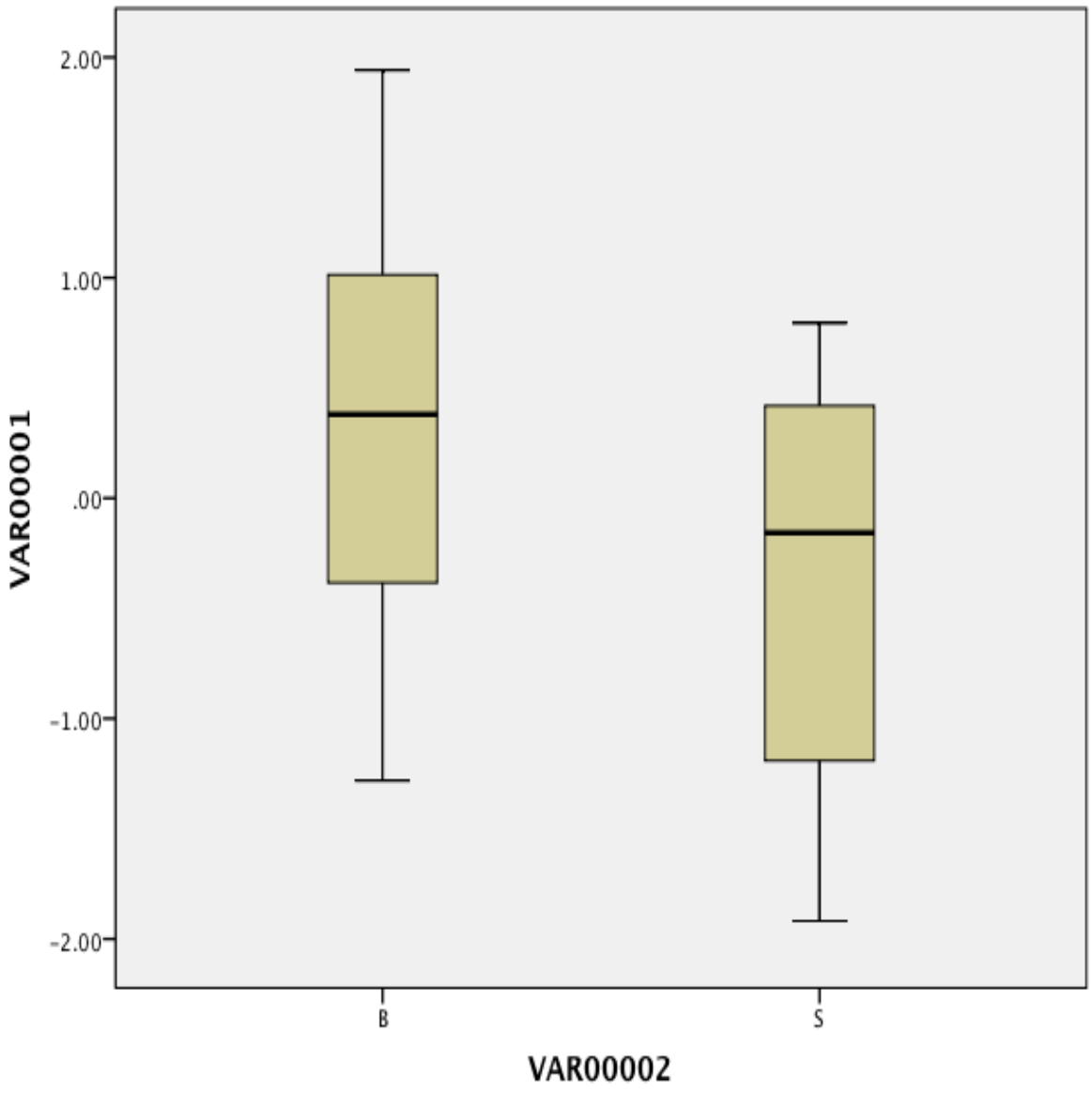

***Graph 1*** *Boxplot, Mean averages for BAREFOOT and SHOD measures*

**Feeling Scale Measures for Barefoot and Shod Performance**




***Graph 2*** *Boxplot, Mean averages for BAREFOOT and SHOD measures*

**POP Scale Measures for Barefoot and Shod Performance**




***Graph 3*** *Boxplot, Mean averages for BAREFOOT and SHOD measures*

## 4. CONCLUSION/DISCUSSION

Results from the current study revealed that runner's in the BAREFOOT condition felt better throughout the endurance race compared to when running SHOD. The sense of 'feeling better' throughout a race is determined by assessing the level of pain, discomfort, or fatigue prevalent throughout the body. In addition to physically tuning into the body to assess the sense of 'feeling better', there is a mental component involved too. The sense of overall well-being can be elicited by positive thoughts; these thoughts may come from certain psychological skills like imagery.

Runner's that are custom to running in Five-Fingers most likely have had good experiences while running with them in the past, these positive thoughts can attribute to the overall sense of well-being throughout their race. There could be implications on the effectiveness of training in Five-Fingers as a result of participants feeling better in this condition. Runners often train to prepare for endurance events whether it is short distance or long distance. There may be a positive effect on training as a result of running in Five-Fingers. Training in Five-Fingers may cause runners to feel less fatigue and pain within their muscles, which could lead to a quicker recovery period. Another benefit could even be less chance of injury due to a quicker recovery period. Training can be vigorous; alleviating the possibility of overuse injuries will help runners perform at peak condition.

Subjects were trained barefoot runners, but there was still a range of athleticism across participants. Some runners were more recreational while others were highly motivated by performance. This range in subjects may have been one limitation to the study and could account for some variability in the data, but regardless of these differences ***all*** of the subjects felt better running in the BAREFOOT condition. One does not have to be a high profile athlete to feel

good running or exercising in Five-Fingers. Additionally, if people feel better throughout exercise they may even be inclined to exercise for a longer duration. Staying physically active and engaging in regular physical activity is important for maintaining good health and overall well-being.

The endurance run in the current study was only two miles, and participants felt significantly better during this two-mile race in the BAREFOOT condition. If participants felt better during a short two-mile race this may have implications regarding *feeling* over a larger scaled race as well. Further research could be done to investigate how subjective measures such as the RPE, FS, and POP scales may be affected over a longer distance endurance race. If participants felt better running over a longer distance, there may be some effect on measures like time to completion and RPE scale measure of intensity that were not able to be displayed in the shorter race distance.

The significance of feeling better while running could be associated with altered biomechanics of running. Research has been done on foot strike and stride length in regards to the BAREFOOT and SHOD condition. BAREFOOT runners tend to have a forefoot or mid-foot strike; whereas, SHOD runners typically heel strike. One researcher, Dr. Lieberman, has examined running biomechanics of SHOD and BAREFOOT runners in conditional running shoes and barefoot; he reported that runners in conditional running shoes had greater transient impact with each stride (up to three times an individual's body weight of force upon impact). Lieberman concluded that forefoot striking resulted in no transient impact with each stride. More investigation should be done regarding injury prevention and barefoot running, more specifically, how foot strike and gait can reduce force of impact and prevent overuse injuries.

Running in a minimalist shoe enables people to feel better, but there may be a physiological explanation behind the sense of 'feeling good'. During an endurance run, the sense of well-being can be a result from changes in the endocrine system (Nudel 2002). While exercising, there are various types of neurotransmitters that are released into the blood stream and the brain. These substances can have positive and even in some cases euphoric type effects on the body. This study did not identify the type and amount of neurotransmitters found in the brain after BAREFOOT/SHOD trials. More research needs to be done exploring the relationship between neurotransmitters (i.e. amount and specific type) and their effect on emotions during exercise. As of now, the effect of exercise on emotion is not well understood. If a causal relationship was discovered between high levels of certain neurotransmitters and positive emotions during exercise, then this confirmation would help solidify a positive psychological benefit to exercise. Also, there may even be other positive effects of these neurotransmitters besides increased well-being that may be explored in future studies.

Running BAREFOOT or in a minimalist type shoe has now been proven to have significant psychological benefits, but further investigation should be done regarding effect of exercise on physical emotions and physiological measures.

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